7.3 CAMA with Subscriber Specific Pseudo ANI

The emergency service call is made over a CAMA trunk. The 7 (or 8) digits of ANI information are used to convey a pseudo ANI. The pseudo ANI is usually used to identify the caller's serving cell (or sector) and the caller. The caller's identity is temporary, but it allows other information to be correlated. For instance, a directive could be used to convey specific information about the call (caller identification information, location information, etc.) This information may be correlated using the pseudo ANI. The information may be stored in an Automatic Location Information (ALI) database and be retrieved using normal E9-1-1 call procedures.

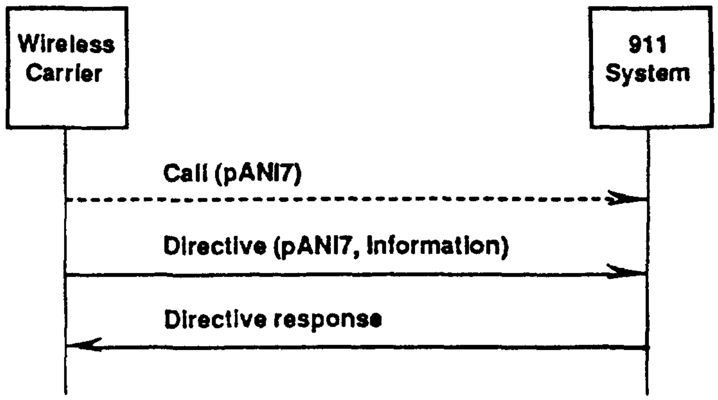


Figure 3: Information Flow with CAMA Pseudo ANI and an Information Bearing Directive

7.4 Call Setup with Additional Information (ISUP)

The emergency service call is made over an ISUP (Integrated Services Digital Network User Part) trunk modified to carry additional information about the call (caller identification information, location information, etc.). This method for information transfer is direct and does not require correlation of other messages. ISUP may not have sufficient bandwidth for the intended information flow and ISUP does not have procedures for additional messages to request and deliver location information.

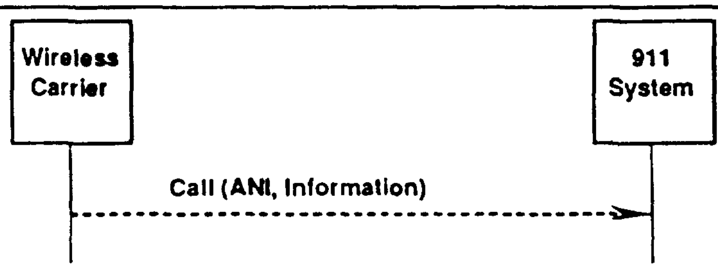


Figure 4: Information Flow with ISUP Call Associated Signaling to Carry Information

7.5 Call Setup with Additional Information (TCAP)

The emergency service call is made over an ISUP trunk. The ANI information correlates the call to the call information conveyed via the SS7 Transaction Capability Application Part (TCAP). This method for information transfer is direct and does not require the retrieval of other information.

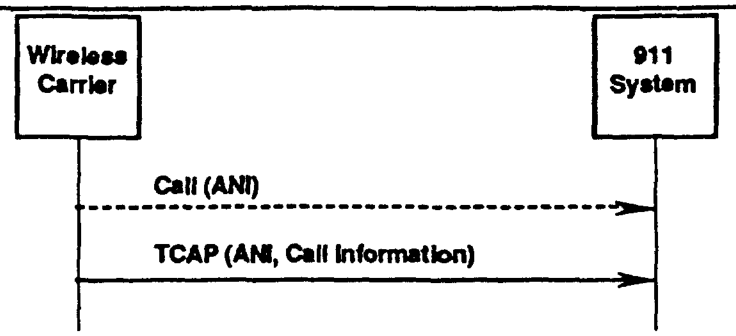


Figure 5: Information Flow with ISUP Call Associated Signaling to Carry Information

7.6 Call Setup with Additional Information

The emergency service call is made over a CAMA trunk. The 7 (or 8) digits of ANI information are used to convey a pseudo ANI. The pseudo ANI is usually used to identify the caller's serving cell (or sector) and the caller. The caller's identity is temporary, but it allows other information to be retrieved. For instance, more information may be requested that could be used to convey specific information about the call (caller identification information, location information, location updates, etc.).

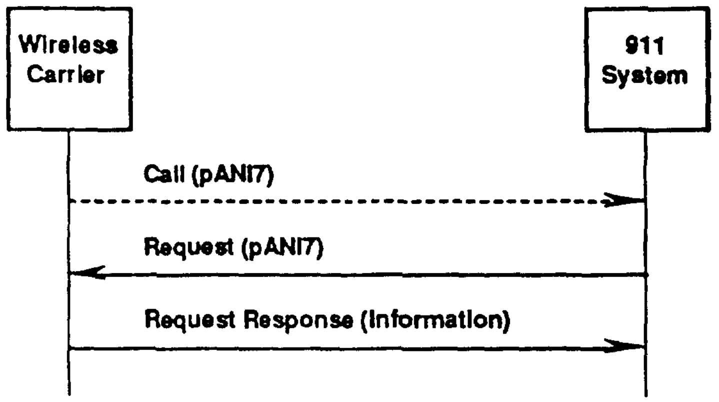


Figure 6: Information Flow with CAMA and Non-Call Associated Retrieval of Information

7.7 Call Setup with Additional Information

The emergency service call is made over an ISUP trunk. The ANI information identifies a caller. The caller's identity is temporary for some mobile subscribers, but it allows other information to be retrieved. For instance, more information may be requested that could be used to convey specific information about the call (caller identification information, location information, location updates, etc.).

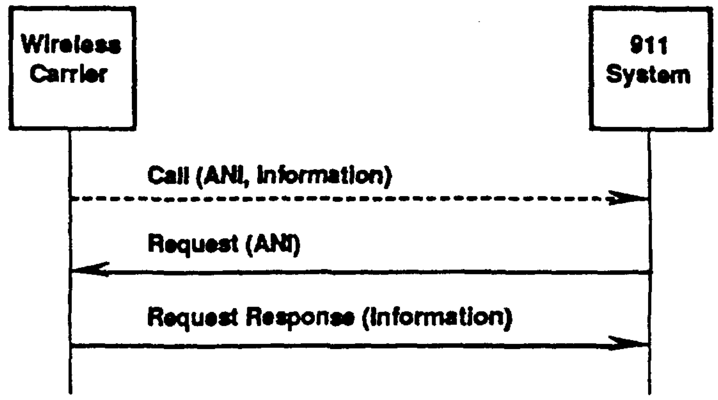


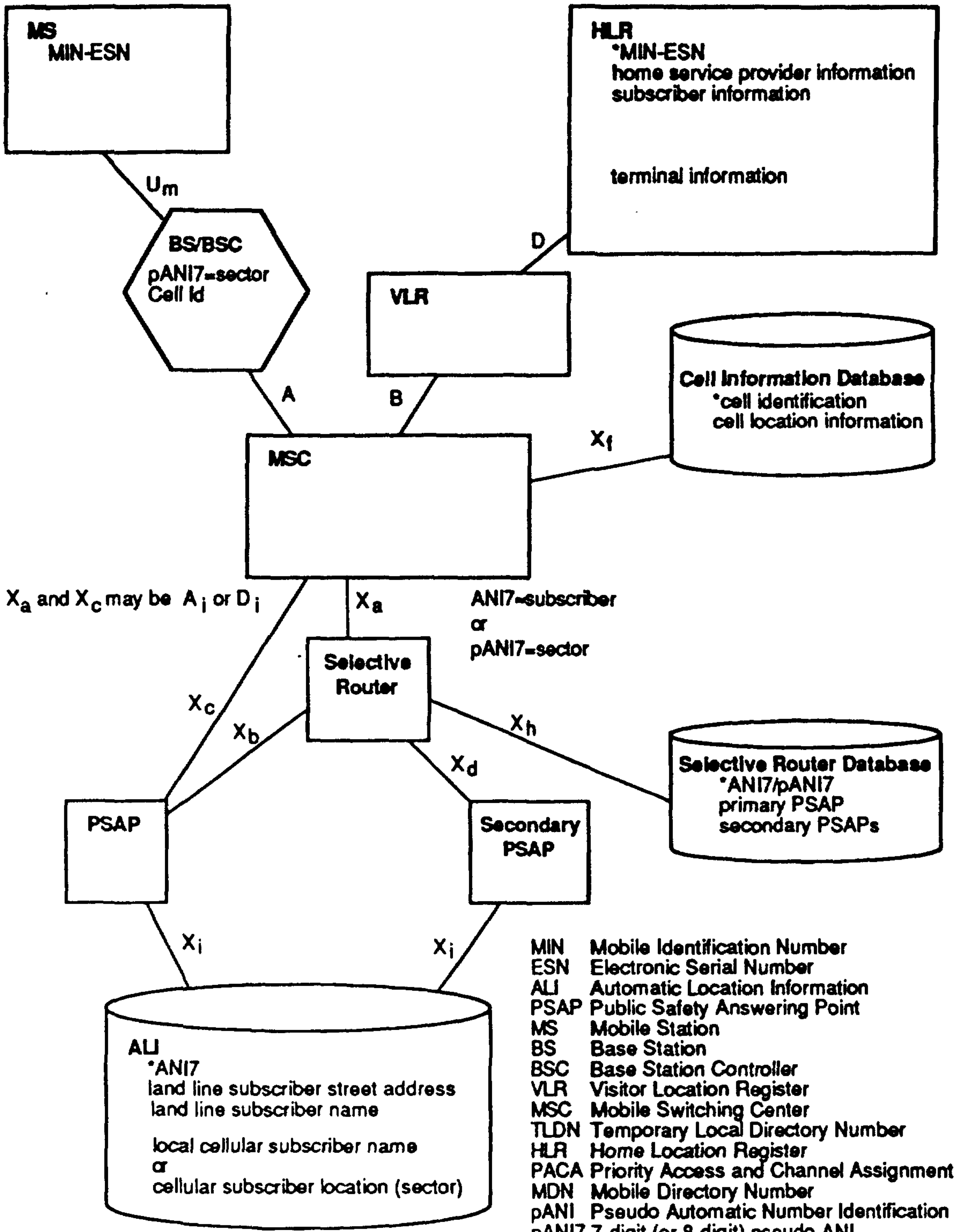
Figure 7: Information Flow with ISUP and Non-Call Associated Retrieval of Information

8. Information Elemennt Sources

Note: reference points arand network elements not germane to emergency service information elemement sources have been excluded for the sake of clarity. ANI refers to a a full 10-digit (or greater) identification of the calling subscriber. ANI7I7 refers to a restricted 7- and 8-digit ANI.

The A, B, D, U_m, D_i, arand A_i are existing interfaces.

X_a, X_b, X_c, X_d, X_f, X_h, X_i, X_k, X_m and X_n are possible new interfaces.



MIN	Mobile Identification Number
ESN	Electronic Serial Number
ALI	Automatic Location Information
PSAP	Public Safety Answering Point
MS	Mobile Station
BS	Base Station
BSC	Base Station Controller
VLR	Visitor Location Register
MSC	Mobile Switching Center
TLDN	Temporary Local Directory Number
HLR	Home Location Register
PACA	Priority Access and Channel Assignment
MDN	Mobile Directory Number
pANI	Pseudo Automatic Number Identification
pANI7	7-digit (or 8-digit) pseudo ANI
ANI7	7-digit (or 8-digit) ANI
*	database key
•	change from the previous figure

Figure 8: Evolutionary Path A Information Element Sources

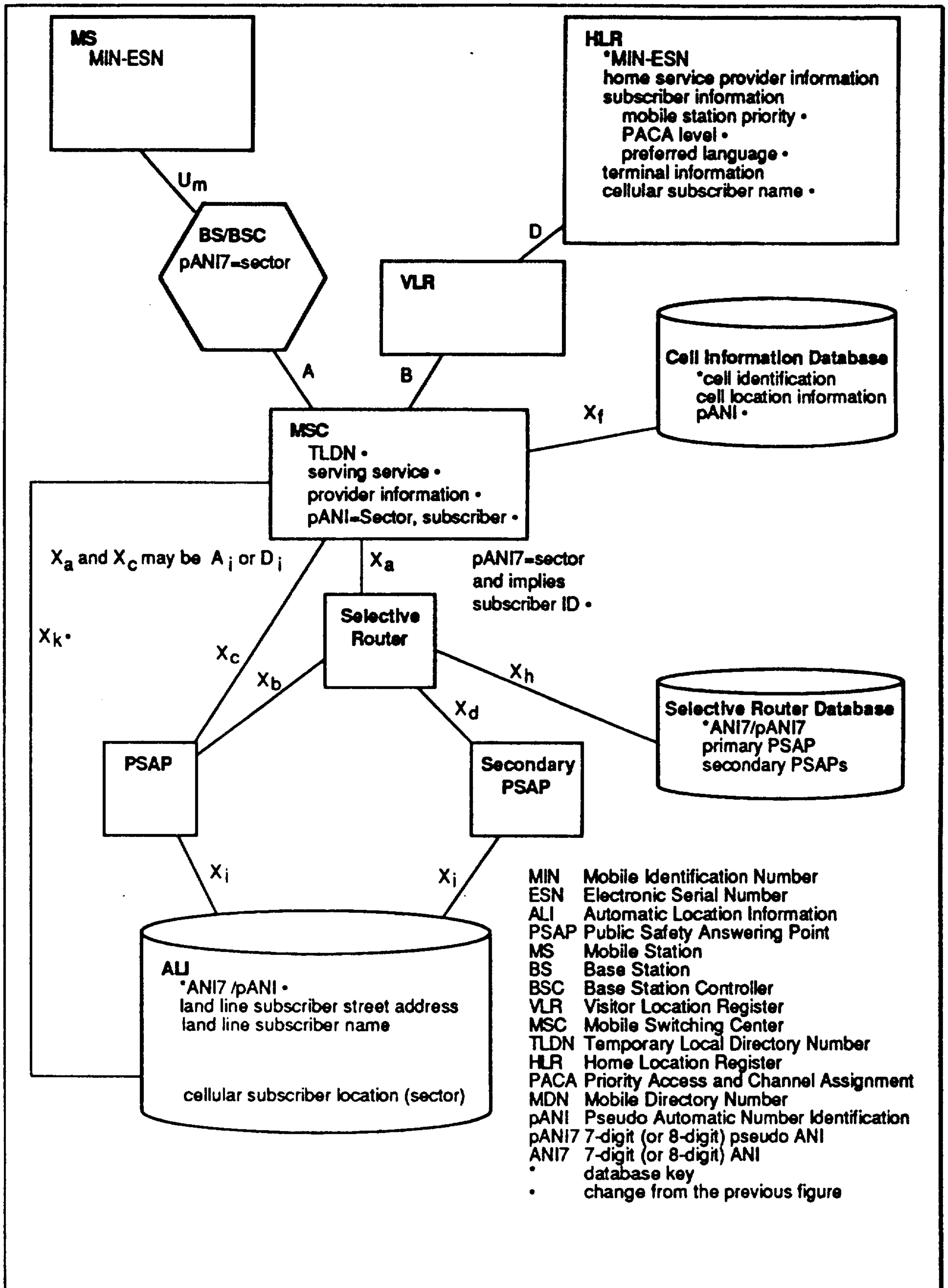


Figure 9: Evolutionary Path B Information Element Sources

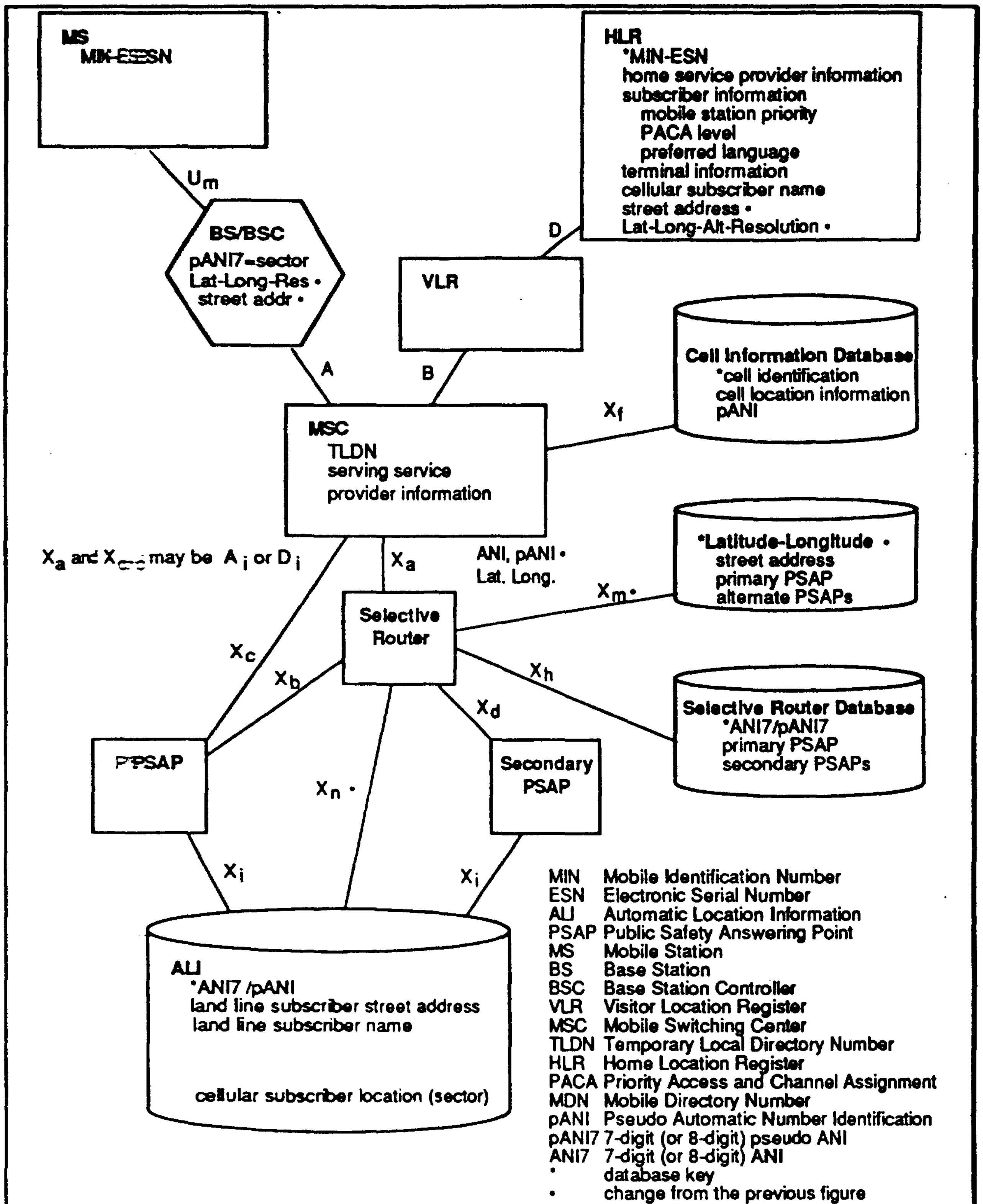


Figure 10: Evolutionary Path C Information Element Sources

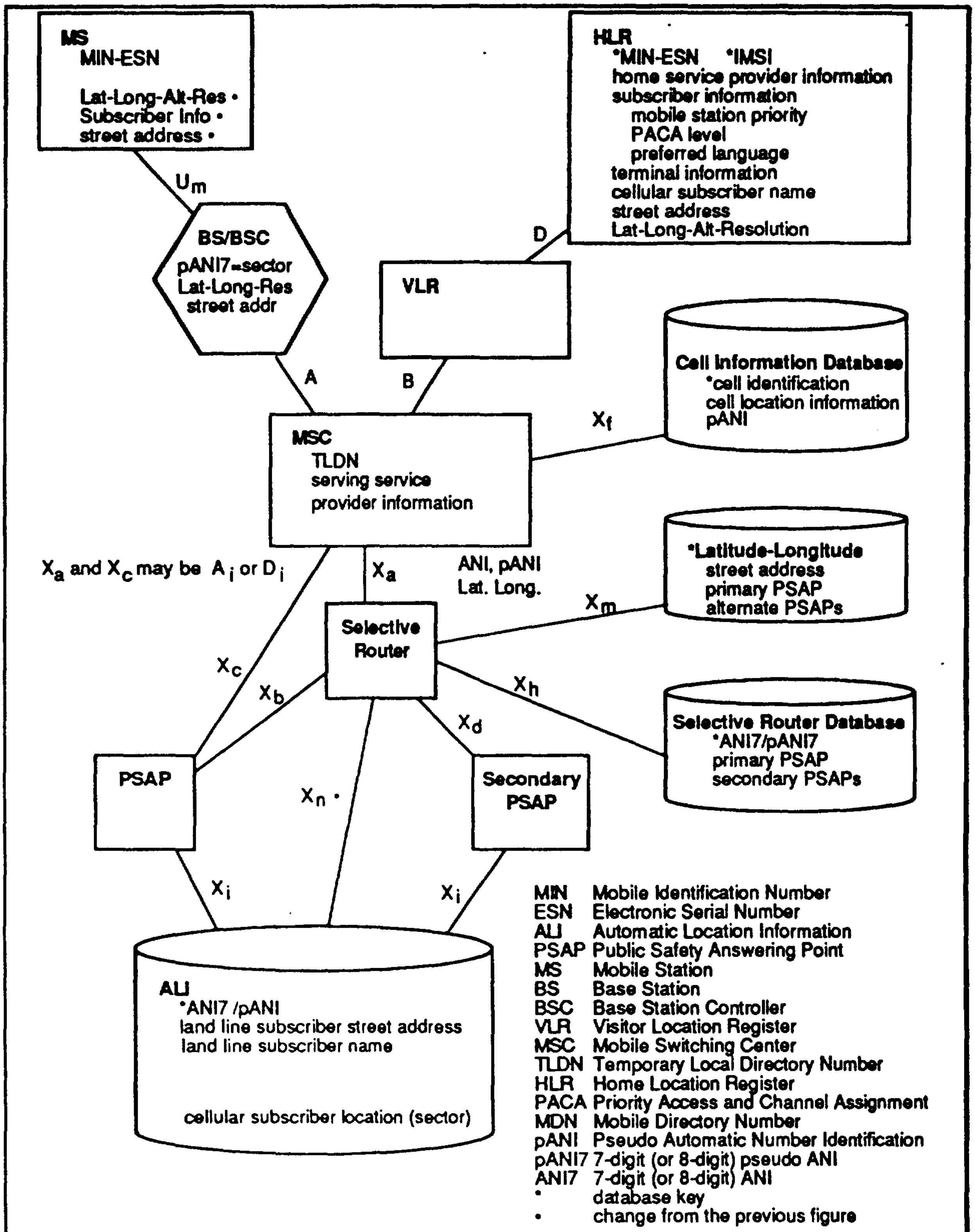


Figure 11: Evolutionary Path D Information Element Sources

9. Location Technologies

A number of wireless caller location technologies were presented. The technologies are available or are proposed and have different capabilities. Approaches ranged from equipment placed at the cell site (requiring little or no change to the mobile station) to autonomous position determination equipment placed in the mobile station. Contribution WJEM(911)/94.10.11-011 (a report commissioned by APCO and the State of California) contained synopses of methods and products to determine position.

9.1 Minimum Location Requirements

Establishment of definitive minimum requirements at this time may be premature. However, there are certain generic requirements that can be postulated.

9.1.1 Time Requirements

Location information is used to support two parts of the delivery of the 9-1-1 call to the Emergency Response System:

- Routing a 9-1-1 call to an appropriate PSAP
- Facilitating the emergency service response itself

The time requirements associated with the above may in fact differ:

- Caller location information sufficient for routing a 9-1-1 call to an appropriate PSAP should be available within, and not delay, the normal call processing interval.
- More accurate caller location information designed to facilitate emergency response should be displayed at a PSAP call taking station no later than 5 seconds from the time the PSAP receives the call.

The realization of these requirements is contingent on technical and economic feasibility.

9.1.2 Minimum Requirements

- In the event that time does not allow the use of the most accurate location information possible for routing a 9-1-1 call, the best available location information to support such routing should be provided.
- The best available location information may be different for different systems, as well as for "home" and "roaming" subscribers.
- The public safety community's desire is for caller location information to be as accurate and precise as possible.

- Actual 9-1-1 location information requirements as they pertain to home and roaming subscribers are ultimately implementation issues, subject to local agreements between the service provider and the public safety community.

10. Contributions

The following documents were contributed to the Joint Experts Meeting:

Number	Title	Author
WJEM(911)/94.10.11-001	A Proposed In-Band Message Protocol Set	David Kelley - Terrapin Corp.
WJEM(911)/94.10.11-002	AT&T Public Safety Systems 911 Data Network Solution	Larry Ciesla, Mike Meyer and Carolyn Robins - AT&T
WJEM(911)/94.10.11-003	AT&T Public Safety Systems Common Channel Signaling Network Solution	Larry Ciesla, Mike Meyer and Carolyn Robins - AT&T
WJEM(911)/94.10.11-004	DF Localization for E-911	Charles Hinkle - KSI Inc.
WJEM(911)/94.10.11-005	On-Going Cellular Geolocation Based IVHS Operational Test	Joe Kennedy - Engineering Research Associates
WJEM(911)/94.10.11-006	Call-Before-You-Dig	James Weigant - OneCall Systems
WJEM(911)/94.10.11-007	Emergency Access Position Paper	PCIA, APCO, NASNA
WJEM(911)/94.10.11-008 (same as 033)	TIA TR45 JEM Report on Emergency Services	TIA TR45
WJEM(911)/94.10.11-009	9-1-1...New Jersey's Lifeline	S. Robert Miller - State of NJ
WJEM(911)/94.10.11-010	Priority Cellular Access Service	Randy Schulz - Bellcore
WJEM(911)/94.10.11-011	Survey of Location Technologies to Support Mobile 911	C.J. Driscoll & Associates
WJEM(911)/94.10.11-012 WJEM(911)/94.10.11-013 WJEM(911)/94.10.11-014	Data Considerations for Enhanced 911 Display of Wireless Device Locations	John Melcher - Greater Harris County 911 and Beth Ozanich - Tarrant County 911 District
WJEM(911)/94.10.11-015	User Location Information	Thera Bradshaw, NENA Steve Proctor, UITS Mary Boyd, NASNA
WJEM(911)/94.10.11-016	PSAP Service Requirements	Thera Bradshaw, NENA Steve Proctor, UITS Mary Boyd, NASNA
WJEM(911)/94.10.11-017	E911 CPE Perspective on the Installed Base	Ian McGraw, Plant Equipment, Inc.
WJEM(911)/94.10.11-018	An Approach to Locating Wireless Transmitters for Public Safety	Lou Stilp, Associated Communications Corp.
WJEM(911)/94.10.11-019	Radio Location Technology Evaluation Guidelines	Robert Voss, MCI
WJEM(911)/94.10.11-020	NENA Recommended Formats for Data Exchange	Thomas Hicks, NENA
WJEM(911)/94.10.11-021	NENA Recommended Protocols for Data Exchange	Thomas Hicks, NENA
WJEM(911)/94.10.11-022	NENA Recommended Standard for Street Thoroughfare Abbreviations	Thomas Hicks, NENA
WJEM(911)/94.10.11-023	Wireless Enhanced 911	Mike Lucy, Smith Advanced Technology, Inc. Michael Rendak, Rockwell International Corp.
WJEM(911)/94.10.11-024	911 Tutorial 911 Technology	Joe Blaschka, Adcomm Engineering, Co.
WJEM(911)/94.10.11-025	Effects of Wireless Communications & Advanced Technology on Enhanced 911 Systems	Joe Blaschka, Adcomm Engineering, Co.

Number	Title	Author
WJEM(911)/94.10.11-026	SS7 Data Elements	Joe Blaschka, Adcomm Engineering, Co.
WJEM(911)/94.10.11-027	U.S. Interagency Committee on Search and Rescue (ICSAR) Activities on Use of Mobile Satellite Systems in Search and Rescue (SAR)	Glenn Roach, St. of Mass. 911
WJEM(911)/94.10.11-028	T1P1 & TR46 Network Reference Models	PCIA
WJEM(911)/94.10.11-029	Ground Rules	Gary Jones, JEM Co-Chair
WJEM(911)/94.10.11-030	Proposed Agenda	Gary Jones, JEM Co-Chair
WJEM(911)/94.10.11-031	JEM Schedule	Gary Jones, JEM Co-Chair
WJEM(911)/94.10.11-032	FCC News Release on Action on 911	FCC
WJEM(911)/94.10.11-033	TIA TR45 JEM Report on Emergency Services (same as 008)	Terry Jacobson, AT&T
WJEM(911)/94.10.11-034	Public Safety Answering Point Automatic Location Identification Requirements	Michael Celeski, Pertech America, Inc.
WJEM(911)/94.10.11-035	Overview of a Proposed E911 Wireless Network Architecture Migration Path	US West Communications, Inc. Public Safety Group
WJEM(911)/94.10.11-036	Overview of A Typical E911 Network Architecture	US West Communications, Inc. Public Safety Group
WJEM(911)/94.10.11-037	Wireless Location Overview & Path Forward	F. Warren LeBlanc, US West Technologies, Inc.
WJEM(911)/94.10.11-038	Tutorial on 911 Emergency Services	Mary Boyd, Texas Commission on State Emergency Communications
WJEM(911)/94.10.11-039	JEM Document Assignment	Gary Jones, JEM Co-Chair

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12. Recommendations

Forward the JEM Report to the TIA, Committee T1 and NENA for study and the development of standards for:

- The interfaces and wireless system operations described
- Mobile station enhancements described
- Air interface issues raised

Forward the JEM Report to the FCC, APCO, PCIA, Cellular Telecommunications Industry Association (CTIA), NASNA, North American Numbering Plan Administrator (NANPA), and other interested organizations for their consideration.

Annex A - ALI Information Requirements

This annex applies to evolutionary path A and specifies requirements for the transfer of call related information between the wireless system and the emergency service system in a non-real time mode.

A. Calling Party Number

- ANI

B. Calling Party Address

- For Home System subscribers, this field may contain the subscriber's billing address (at the option of the PSAP).

C. Customer Name

- For Home System subscribers, this field may contain the name of the subscriber.

D. Class of Service

- Mobile = 8

E. Type of Service

- Published = 0
- Non-published = 3

F. Exchange

- Text that indicates type of Wireless Service Provider
  - "Cell" = Cellular
  - "PCS" = Personal Communications Service/Network
  - "MSS" = Mobile Satellite System

G. Emergency Service Number

- Assigned by the PSAP

H. Main NPA and Number

- Directory number of the serving Wireless Service Provider

I. Company ID

- Assigned as required

J. Comments

- PSAP defined remarks.

Annex B - Position Location Capability

This section is included for information purposes only and is not an attempt to endorse any particular technology.

B.1 Introduction

This section gives a brief description of technologies, either existing or proposed, that may provide the information necessary for emergency service providers to locate a 9-1-1 caller who is using a mobile station.

While this JEM report is focused on CMRS, it is important to note that another major effort is underway in the U.S. The Department of Transportation, which has initiated its Intelligent Vehicle Highway System (IVHS) program, relies heavily upon untethered communications and location information to deliver a major portion of its anticipated benefits. Synergy between CMRS and IVHS is expected to produce cost effective solutions for the public safety community.

B.2 Location Technologies

Although every attempt has been made to include, at least from a generic standpoint, existing or emerging technologies, some may have been inadvertently omitted. Time and interest will likely attract other entrants into the process.

As the following figure shows, location technologies can be generically categorized.

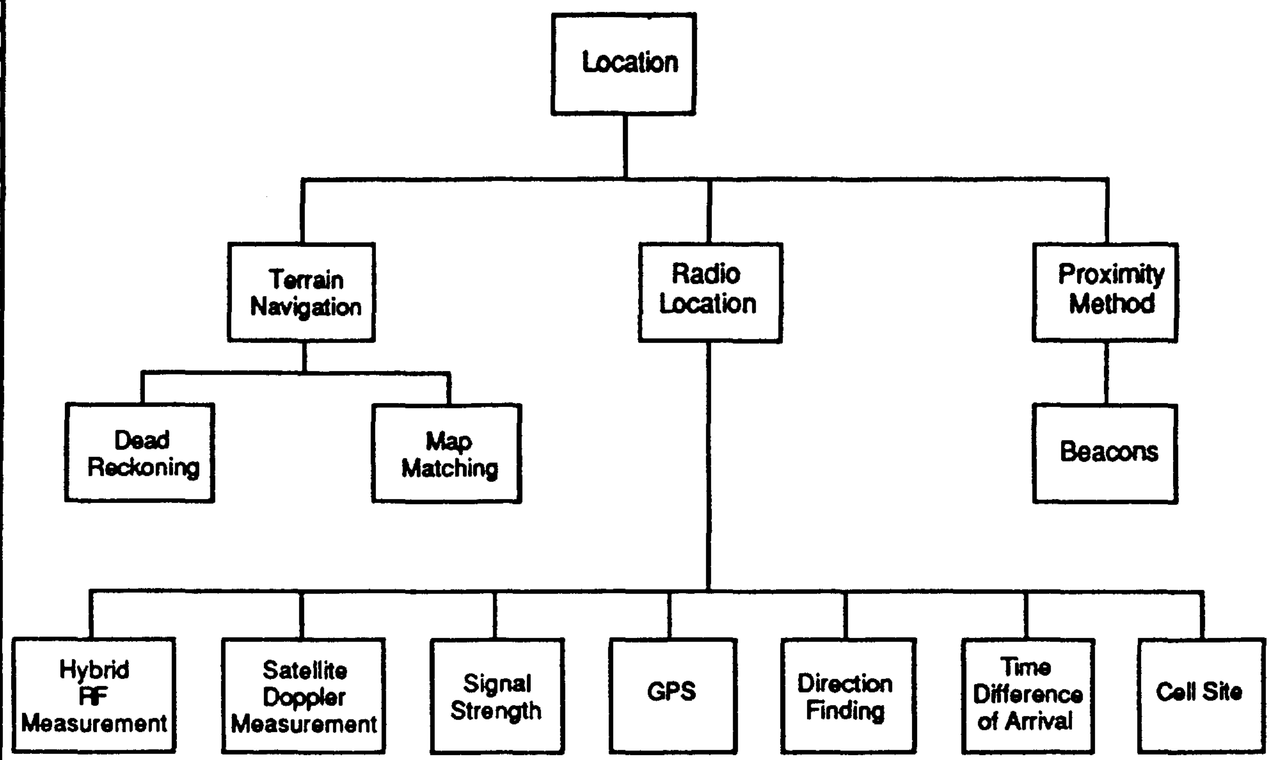

Figure B.1 Location Technology Categories

Techniques for providing position/location can be described in the following generic terms:

- Direction Finding (DF)
- Time Difference of Arrival systems (TDOA)
- Global Positioning Systems (GPS)
- Terrain navigation - dead reckoning and map matching
- Hybrid measurement techniques
- Satellite Doppler measurement systems
- Loran-C
- Other land-based radiolocation systems

B.2.1 Direction Finding

Direction Finding (DF) systems, also referred to as Direction-of-Arrival (DOA) or Angle-of-Arrival (AOA) systems, detect radio frequency (RF) emissions using phased-array antennas and receivers that operate passively in the wireless frequency bands. DF systems process the signals to determine their angles of arrival. Upon detection at two or more antenna sites, the calculated directional information is then passed to a central control location where location is computed. DF is thus used in network-centric system configurations.

B.2.2 Time-Difference-of-Arrival

Time-Difference-of-Arrival systems measure the differences between the arrival times of the signal at different receivers (base stations). The path that would be followed by a TDOA transmitter traveling in a manner that maintains a constant time-of-arrival difference between any pair of base station receivers is a hyperbola. The transmitter (e.g. mobile station) is located at the point of intersection of two hyperbolas based on time of arrival difference measurements at three base stations. TDOA is used in network centric systems to compute caller location using signals transmitted from a wireless phone.

B.2.3 Global Positioning System (GPS)

GPS is available for public use. To provide the location information at an external site, a communication capability in the mobile system is used. The satellite signals can be blocked by buildings or foliage.

Satellite systems other than GPS which provide for communications and radio determination, typically rely on signals transmitted to or from three or more satellites (or two satellites and a fixed ground station) to a receiver.

B.2.4 Other Land-Based Radiolocation Systems

Other land-based radiolocation systems have been developed which use signals from existing non-telephony networks (e.g., FM) or private base stations to compute location using triangulation, TDOA or other techniques. In addition, Automatic Vehicle Monitoring (AVM) systems have been deployed in a number of U.S. cities which compute location by measuring time difference of arrival of signals transmitted from in-vehicle transponders to multiple network base stations. Data from base stations is transmitted to a control center, where location is computed.

B.2.5 Hybrid Measurement Techniques

Hybrid measurement techniques can be supersets or subsets of other described techniques or may employ RF measurement techniques, which rely on the wireless communications channels between the mobiles and base stations or radio ports. Examples of measurements include signal strength, word or bit error rate and signal-to-noise ratios. Measurements may be taken in both uplink and downlink directions. Data reduction methods may be performed on data collected from the RF measurements in order to determine a correlation with location.

B.2.6 Terrain Navigation

Terrain navigation systems use what is called "dead reckoning" (DR) or "map matching". In a DR system, calculations are made on distance and direction traveled relative to where the vehicle started or was last calibrated. These systems use sensors on the vehicle to measure parameters such as tire rotation for distance and compass orientation for direction. These systems can transmit coordinate data to a user base station, through a communication device installed in the vehicle. To maintain accuracy, these systems require periodic calibration through integration with another system such as a map matching and/or a satellite positioning system.

Map matching systems use DR techniques, but also include processing of the sensor information in concert with a data base containing the area road and street structure. The calculated locations can be continuously adjusted to conform to the nearest "known" street. When significant changes in direction are detected, they are matched to the most likely feature represented in the map data which is used to adjust the assumed vehicle location. This approach assumes that processing and database facilities are installed at a site external to the vehicle, and that the vehicle communicates with that site.

B.2.7 Satellite Doppler Measurement Systems

The high velocity of low earth orbiting satellites relative to a mobile station, causes an apparent shift in transmitted radio frequency known as Doppler shift. Techniques exist for using the Doppler shift to locate the mobile station.

B.2.8 Loran-C

Loran-C is a low frequency (90-110 kHz) transmitter network. For position determination, a Loran receiver in a vehicle receives the reference signals and determines the vehicle's latitude and longitude. As needed, location information is transmitted from the vehicle to a site external to the vehicle through a communications device. The accuracy on land is often degraded due to weather conditions and electrical interference. No contributor to the JEM proposed a solution using Loran-C.

B.3 Location Technology Considerations

B.3.1 Multiple Location Technologies Exist

There are multiple location technologies that may be used to determine the location of a wireless device. A list of location technologies submitted to this JEM are included in this Report. Not all the technologies address the multiple RF air interfaces, system architectures, and operating environments which exist (e.g., 800 MHz PCS) or are proposed (e.g., 1800 MHz PCS).

B.3.2 Location Technologies Are Not Mature

Location technologies applicable to CMRS to satisfy the 9-1-1 needs are not mature. Location technologies should be functionally integrated into wireless terminals, base station systems, wireless switching and intelligent network systems, as required, to provide end-to-end solutions.

Performance analysis of the location technologies for various architectures and operating environments will require additional development and testing.

B.3.3 Multiple Architectures Exist

The following architectures may be used for CMRS:

- Megacells - Satellite Based Systems
- Macrocells
- Microcells
- Picocells
- Distributed Antennas:
  - — Remote Antenna Driver Systems (RADS), Remote Antenna Signal Processors (RASPS)
  - — Coax /Fiber Distribution
- Repeaters/Enhancers/Translators
- Omni/Sectored/Smart antenna configurations
- Three Dimensional Cell Structures
- Hierarchical Cell Structures (multi-layer)

B.3.4 Multiple Physical Environments Are Present

CMRS may operate in the following environments:

- Dense urban (e.g., New York City)
- Urban
- Suburban/rural
- Indoor (from skyscraper to farmhouse)
- Highway
- Outdoor (water, open field, forest, etc.)
- Three dimensional cell structure (e.g., floors in a building)
- Other (subway/enclosed stadium)

B.3.5 Multiple Radio Air Interfaces Must Be Accommodated

For the 800 MHz band the following air interface technologies are already deployed or have been proposed:

- AMPS (EIA/TIA-553, TIA/EIA *IS-91*)
- NAMPS (TIA/EIA *IS-91*)
- TDMA (TIA/EIA *IS-54-B*)
- CDMA (TIA/EIA *IS-95*)
- Extended TDMA (ETDMA)
- Interdigital Corp. Overlay Broadband CDMA
- Motorola MIRS ESMR
- Geotek ESMR

The following are JTC[1] Candidate Technologies for 1800 MHz:

- Up banded *IS-54*
- 1.25/2.5 MHz CDMA
- 5 MHz CDMA
- PCS1900
- PACS

[1] Joint Technical Committee on Wireless Access

- Omnipoint Hybrid TDMA/CDMA
- DCTU

Other air interface technologies, including satellite based systems, are under development and may be deployed.

B.3.6 No Integrated Solutions Evident Today

Efforts to integrate the various location technologies into CMRS by system infrastructure and subscriber equipment vendors are in the formative stages. No contributions were submitted by any CMRS equipment manufacturer (including 800 MHz and 1800 MHz PCS) regarding their current abilities or deployment plans for radio location equipped systems. Only contribution WJEM(911)/94.10.11-009 described an integrated end-to-end test (i.e., prototype) system capable of call routing to a PSAP based upon location.

B.3.7 System Impacts May Be Significant

The adoption of a location technology may impact many network elements of CMRS including mobile stations, base station systems, MSCs, HLRs, VLRs, and intelligent network systems. The magnitude of the impact varies depending on the location technology chosen. No location solution is impact free.

B.3.8 Implementation Is An Evolutionary Process

The merging of location technologies into existing and emerging wireless systems is an evolutionary process that will take time and will probably be implemented in a phased approach.

The following recommendations are made:

- Evaluation of any location technology should be done for the various air interfaces, system architectures and operating environments. This will allow for determination of applicability and performance for each candidate technology.
- Integration into existing and new RF/switching infrastructure is critical. Further investigation into product availability is warranted.
- Conceivably, incompatible location technologies may be deployed in markets with compatible air interfaces, by different license holders. This could result in degraded ability to provide location information for mobile stations that are designed for other licensees' systems. Standards should be required to provide default location information capability.